THE EFFECT OF INCREASED INFORMATION PROCESSING ON SINUS ARRHYTHMIA AND HEART BEAT

by

Donald Edward Bonsper

United States
Naval Postgraduate School

THESIS

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Donald Edward Bonsper
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B.S., United States Naval Academy, 1965

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ABSTRACT

This experiment investigated the effect of increased information processing on heart beat and sinus arrhythmia. A measure of sinus arrhythmia was developed which considered the area between the electrocardiogram rate curve and the average heart beat line. Simple linear correlation analyses were performed to determine the relationships between heart beat, sinus arrhythmia and information processing rate. Sinus arrhythmia was decreased as a result of increased information processing while heart beat was not significantly affected.

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I. INTRODUCTION

Industrial engineers, as part of their profession, are sometimes concerned with the mental workload and information processing demands placed on workers. Usually attempts are made to reduce the mental load so as to relieve stress and mental fatigue. It is interesting to consider the possible effects of increased information processing on certain physiological functions of the body. For example, what effect does an increase in information processing have on heart beat or on heart rate? Heart rate introduces yet another concept.

The average human heart is very irregular in its performance. There is an increase in heart beat during inspiration and a decrease during expiration. The magnitude of these changes varies with the individual. At times the phenomenon is the exact reverse of that described above (Herrmann, 1944). Nevertheless, the heart does not beat at a constant rate. This change in heart beat as a function of normal breathing is known as sinus arrhythmia. It is considered normal in youthful hearts and is not a necessary cause for concern. A considerable degree of sinus arrhythmia may be found in older persons with arteriosclerosis or coronary disease and is a distinctly abnormal sign. In addition, there are many other types of arrhythmias that are serious cardiac diseases.

This experiment supports the work of Kalsbeek (1968). Kalsbeek used an increase in the number of binary choices per minute as his increase in mental load. However, this experiment has not only increased the binary decisions per minute but actually increased the amount of information that must be processed.

Consistent with information theory (Bell, 1953), one bit of information is the amount of information required to make a decision between two equally likely alternatives. Two bits of information provides sufficient information to make a decision among four equally likely alternatives (Poock, 1967). The actual number of bits of information is found by taking the log to the base 2 of the number of equally likely alternatives.

This experiment has increased the amount of information processed by using three levels. The first level is a resting state and does not require any information processing. The remaining two levels represent an increase in information processing in that they require either one or two bits of information.

In addition, a new measure of sinus arrhythmia has been used. Kalsbeek developed an irregularity score by counting the frequency of times the electrocardiogram exceeded certain values. The method does not account for extended periods of an increased rate nor does it differentiate between one period of a high rate and number of periods of a slower rate. As a result a better method of scoring sinus arrhythmia was sought.

Therefore, it was decided to design an experiment that could investigate the effects of increased information processing on heart beat and sinus arrhythmia. It was also decided to develop a better measure of sinus arrhythmia.

II. METHOD

A. APPARATUS

The experimental equipment is divided into two areas. The first area concerns the presentation of the information processing levels and the recording of the subjects' response times. The second area concerns the monitoring of the electrocardiogram (heart beat) and the electrocardiogram rate curve.

To present the different levels of information processing a visual test similar to that of Poock (1967) was used. The subjects (Ss) responded to numbers on a 2-1/4"x 1-1/2" transilluminated screen.

The one bit decision was generated by using the numbers 2 and 3 as the equally likely alternatives. The two bit decision was generated by using the numbers 1, 2, 3, and 4 as the equally likely alternatives. The Ss responded to the illuminated numbers by pushing buttons on a 7" x 9" response panel. The buttons were numbered 1-4 from left to right. Each subject used his index fingers of both hands for the one bit decision. That is, the index finger of his left hand was the number two and the index finger of his right hand was the number three. During the two bit decision each subject added the middle finger of both hands. Therefore the middle finger of his left hand was number one, the index finger number two, the index finger of the right hand number three and

the middle finger number four. The buttons on the response panel were placed so as to allow for the normal difference in length between the index and middle fingers.

The signals (110 signals at each level) were sent for 8-10 minutes. The signals were sent manually by the experimenter (E) with a 5" x 7" control board with four numbered buttons. All buttons were silent. Ss response times were recorded in milliseconds.

A Beckman type RM Dynograph Recorder was used to monitor the heart beat and electrocardiogram rate. The recorder was wired so that both the heart beat and electrocardiogram rate could be observed simultaneously. The dynograph used a cardiotachometer coupler to calculate the electrocardiogram rate. The cardiotachometer observes the time between successive R waves and then calculates the rate if the heart were to continue with R waves that far apart. The calculated value is plotted as a point on the electrocardiogram rate curve. The total plot of all such points is called the electrocardiogram rate curve and represents the changes in heart rate between heart beats. Both the heart beat and electrocardiogram rate were printed out on Beckman Dynograph paper. Beckman electrodes were used to connect the subjects with the machine.

B. TEST SITE AND SUBJECTS

The experiment was performed in the Human Factors Laboratory at the Naval Postgraduate School. Ss were seated in a chair with the transilluminated screen and response panel in front of them on a table.

The 24 subjects were all male officer students from the Naval Postgraduate School. Their ages varied between 25-36.

C. PROCEDURE

Upon entering the laboratory each subject was instructed to strip to the waist. The Beckman electrodes were then placed on his chest and he was seated. The instructions for the experiment were explained while E adjusted the dynograph in order to get a good electrocardiogram and electrocardiogram rate on the recorder. It was explained that the experiment would consist of three parts. Part one would be five minutes of resting. Part two would be 8-10 minutes of observing and responding to either a 2 or 3 on the transilluminated screen while part three would be 8-10 minutes of observing and responding to one of the numerals 1, 2, 3, or 4 on the screen. The subjects were instructed to push the button corresponding to the number on the screen until the number disappeared. They were also instructed to push only one button at a time and to respond as quickly as possible. The numbers were sent in random order at each decision level.

Ss had an opportunity to respond to each number twice in a practice mode. Upon completion of the instructions, Ss relaxed and did nothing for five minutes. The subjects then responded to the binary decision for 8-10 minutes (110 signals), rested one minute and then responded to the 2 bit decision for 8-10 minutes (110 signals). E recorded the response time for each decision. Upon conclusion of the experiment, E explained, in general, the purpose and objectives of the experiment.

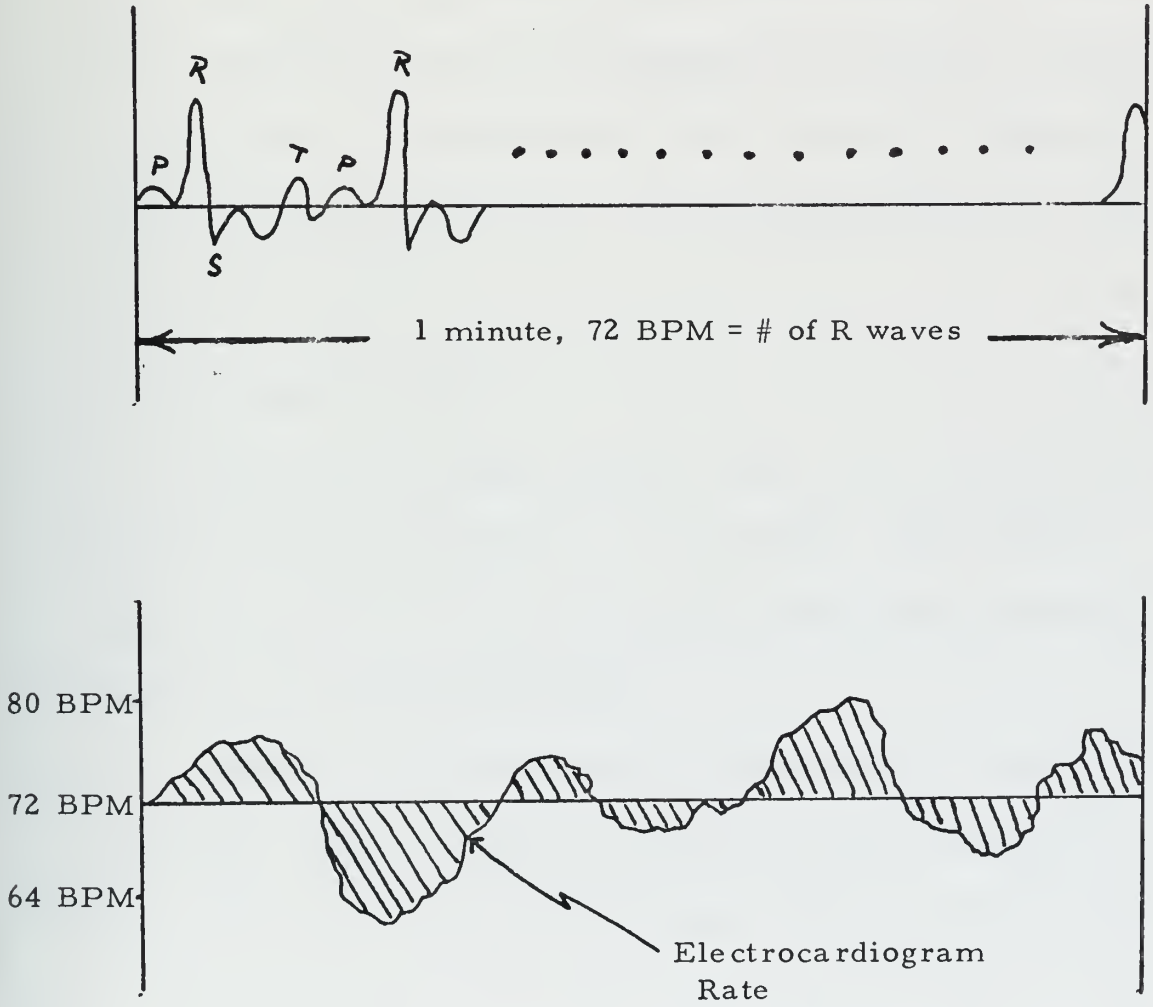
D. REDUCTION OF DATA

At the conclusion of the experimentation there were 24 electrocardiogram traces (heart beat) and 24 electrocardiogram rate traces. In addition, there were 110 response times (corresponding to the 110 signals) for each subject for each of the one and two bit decisions.

The first analysis of the data dealt with the response times. Each set of 110 data points was analyzed and unrepresentative values were discarded with discretion. In addition, other values were eliminated randomly to reduce the number of points to 100 for mathematical ease in the computations. These 100 points were then averaged. As a result, the data were now reduced to one value for each subject at each level of information processing. That is, 2 values for 24 subjects or 48 data points.

The most complex reduction involved the traces of heart beat and electrocardiogram rate. The heart beat for each minute of

the experiment was determined by counting the R waves. For each corresponding minute on the electrocardiogram rate curve, a straight line was drawn to represent the average heart beat (obtained from electrocardiogram) in that minute. The areas on either side of this straight line (see Fig. 1) and the electrocardiogram rate curve were calculated using a two wheeled integrator-planimeter. Values were accurate to three places. This area for each minute was used as a measure of the sinus arrhythmia.



Shaded Area Represents Measure of Sinus Arrhythmia

Figure 1

At this point, there were five values of heart beat while resting, 8-10 values at the one bit decision level and 8-10 values at the two bit decision level for each subject. Additionally, there was a corresponding value of sinus arrhythmia for each of the heart beat values. These data were further reduced by selecting minutes 3-7 for each of the information processing levels. Therefore, each subject had five values of heart beat and sinus arrhythmia at each of the three levels: resting, one bit and two bit. For the total experiment with all Ss included, there were 24 times 5 or 120 data points of heart beat and sinus arrhythmia for each level of information processing. These data were further reduced by taking the average of each set of 5 values thus reducing the total to 24 data points for each level.

E. ANALYSIS OF DATA

The values for subject response time were transformed into an information processing rate. For example, if S1 required .5 seconds for the one bit decision then his information processing rate was 1/.5 or two bits/second.

Minutes 3-7 were selected for analysis of heart beat and sinus arrhythmia because it was felt that these minutes were representative of the information processing tasks. That is, during minutes 3-7 at the one bit and two bit levels, Ss' hearts had time to reach and maintain an accurate pattern reflecting the effect of the information increases.

A one way analysis of variance design with repeated measures on the same elements was used to compare heart beat and information processing levels (Winer, 1962). The average values for each subject at each level of information processing were used. This same design was used to compare sinus arrhythmia and information processing levels.

A one way analysis of variance was used to compare information processing rates and information processing levels. Subsequent analysis verified previous experience that no learning occurred during the experiment and each measure was therefore considered independent.

A correlation analysis was performed at both the one bit and the two bit levels. All correlation combinations between sinus arrhythmia, heart beat and information processing rates were considered.

III. RESULTS

Figure 2 shows the results in graphical form. The analysis of variance results, Tables I-III, show:

1. Increased information processing decreases sinus arrhythmia. (p less than .0001).

2. Increased information processing has no effect on heart beat. (p between .75 and .90).

3. Increased information processing of bits increases information processing rate. (p less than .0001).

The correlation results, Tables IV-V, show that all correlation combinations between heart beat, sinus arrhythmia and information processing rates are not significant at the one bit and two bit decision levels.

Duncan Multiple Range Test results, Table VI, show that sinus arrhythmia is significantly reduced at each level.

Table I

Analysis of Variance Model on Sinus Arrhythmia
(Single Factor with Repeated Measures on Same Elements)

Source	ss	df	F	p
Between people	1062735.48	23		
Within people	759933.38	48		
Information Levels	676675.24	2	186.93	.0001
Residual	83258.14	46		
Total	1822668.86	71		

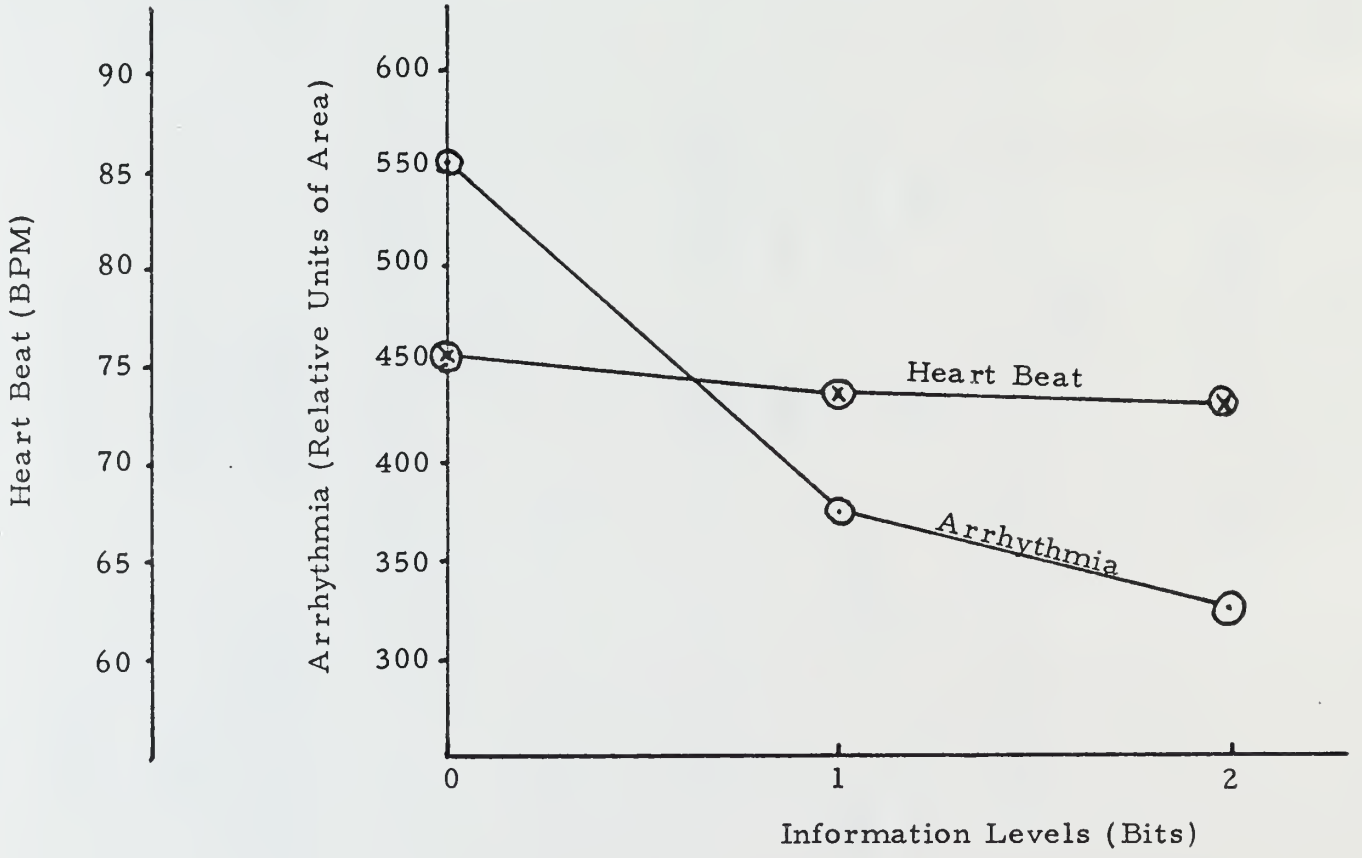

Heart Beat (BPM)
90
85
80
75
70
65
60
Arrhythmia (Relative Units of Area)
600
550
500
450
400
350
300
Heart Beat
Arrhythmia
0
1
2
Information Levels (Bits)

Figure 2

Table II

Analysis of Variance Model on Heart Beat
(Single Factor with Repeated Measures on Same Elements)

Source	ss	df	F	p
Between people	8185.52	23		
Within people	6641.83	48		
Information Levels	81.84	2	.28	.75-.90
Residual	6559.99	46		
Total	14827.35	71		

Table III

Analysis of Variance Model on Information Processing Rates

Source	ss	df	F	p
Information Levels	19.1243	1	215.25	.0001
Error	4.0870	46		
Total	23.2113	47		

Table IV

Results of Simple Linear Correlation
Analysis at 1 Bit Level

Dependent Variable	Independent Variable	Linear Correlation Coefficient (r)
Information Processing rate	Arrhythmia	-0.2998
Information Processing rate	Heart Beat	-0.3273
Heart Beat	Arrhythmia	0.0493

TABLE V

Results of Simple Linear Correlation Analysis at 2 Bit Level

Dependent Variable	Independent Variable	Linear Correlation Coefficient (r)
Information Processing rate	Arrhythmia	0.0371
Information Processing rate	Heart Beat	-0.3734
Heart Beat	Arrhythmia	-0.0553

Table VI

Results of Duncan Multiple Range Test on Sinus Arrhythmia

	2 Bit	1 Bit	Resting
Rank	1	2	3
Mean value	330.62	370.87	553.43

At p equals .01 all levels were found to be significantly different.

IV. DISCUSSION

The area between the average heart beat line and the electrocardiogram rate curve would seem to be an accurate measure of the sinus arrhythmia. The total area might be termed an arrhythmia power function. A two wheeled integrator-planimeter was used to carefully calculate the closed areas for each minute of the experiment thus providing a relative number as a measure of the arrhythmia. This measure of sinus arrhythmia accounts for magnitude, frequency, and duration of variations in electrocardiogram rate.

Before the experiment, it was felt that the increase in information processing would cause an increase in heart beat. It was found, however, that the heart beat averages decreased slightly. The decrease was so small that it was not statistically significant. A possible explanation for the slight decrease may lie in the fact that the arrhythmia decreased. A decrease in sinus arrhythmia implies the heart is more stable and is beating at a more constant rate. The removal of the irregularities could cause a lower average heart beat.

The phenomenon of sinus arrhythmia is not considered to be a serious medical problem. It has been found that deep breathing intensifies it and that breath holding, exercise and atropine abolish it (Corday and Irving, 1961). However, other arrhythmias exist

(e.g., paroxysmal atrial tachycardia) that are not so easily dismissed. Drugs are the usual treatments for these other arrhythmias, but possibly there is a medical application that might utilize information processing in the treatment of irregular hearts. One might treat arrythmia patients with a series of information processing tasks to help stabilize their hearts.

In addition, it has been shown that an increase in the amount of information that a man must process is not always bad for him. At least it causes the heart beat to become more regular and stable.

APPENDIX A

Summary of Observed Data, Minutes 3 to 7, for Sinus Arrhythmia in Relative Area Units

Subject	Resting	1 Bit	2 Bit
1	593, 465, 560, 390 390, (479.6 avg.)	310, 124, 378, 194 480, (297.2 avg.)	333, 512, 358, 373 460, (407.2 avg.)
2	505, 458, 475, 470 252, (432.0 avg.)	295, 266, 306, 243 243, (270.6 avg.)	264, 210, 235, 294 196, (239.8 avg.)
3	513, 733, 590, 708 606, (630.0 avg.)	696, 550, 413, 493 483, (527.0 avg.)	593, 336, 453, 518 338, (447.6 avg.)
4	890, 438, 404, 534 502, (553.6 avg.)	200, 386, 412, 334 260, (314.4 avg.)	318, 210, 308, 200 246, (256.4 avg.)
5	583, 492, 505, 454 377, (482.2 avg.)	220, 432, 419, 329 229, (325.8 avg.)	283, 235, 395, 274 297, (296.8 avg.)
6	695, 585, 663, 750 1000, (738.6 avg.)	279, 450, 503, 494 410, (427.2 avg.)	417, 276, 367, 364 391, (363.0 avg.)
7	423, 481, 538, 453 325, (444.0 avg.)	357, 519, 339, 395 323, (386.6 avg.)	391, 443, 288, 362 305, (357.8 avg.)
8	496, 542, 442, 197 338, (403.0 avg.)	114, 062, 101, 117 081, (95.0 avg.)	165, 160, 176, 058 146, (141.0 avg.)
9	544, 353, 351, 350 308, (381.2 avg.)	234, 268, 401, 291 225, (283.8 avg.)	189, 170, 235, 219 253, (213.2 avg.)
10	538, 468, 492, 395 594, (497.8 avg.)	187, 264, 208, 210 329, 239.6 avg.)	199, 165, 301, 146 257, (213.6 avg.)
11	489, 486, 438, 455 430, (459.6 avg.)	524, 183, 382, 238 392, (343.8 avg.)	460, 255, 232, 360 419, (345.2 avg.)
12	522, 643, 490, 589 535, (555.8 avg.)	311, 273, 359, 494 359, (359.2 avg.)	315, 301, 467, 435 538, (411.2 avg.)
13	403, 296, 258, 398 410, (353.0 avg.)	242, 227, 225, 256 290, (248.0 avg.)	140, 110, 120, 300 184, (170.8 avg.)
14	614, 437, 524, 448 450, (494.6 avg.)	330, 206, 316, 344 397, (318.6 avg.)	262, 223, 389, 205 319, (279.6 avg.)
15	1457, 810, 742, 912 881, (960.4 avg.)	568, 617, 589, 505 679, (591.2 avg.)	667, 570, 556, 696 757, (649.2 avg.)
16	688, 460, 585, 523 568, (564.8 avg.)	385, 366, 288, 311 296, (329.2 avg.)	230, 248, 200, 380 190, (249.6 avg.)
17	555, 790, 501, 561 598, (601.0 avg.)	400, 420, 398, 375 320, (382.6 avg.)	450, 394, 455, 249 425, (394.6 avg.)
18	510, 518, 491, 355 358, (446.4 avg.)	260, 238, 365, 324 390, (315.4 avg.)	176, 133, 175, 220 192, (179.2 avg.)
19	610, 795, 830, 997 1012, (848.8 avg.)	775, 743, 767, 702 865, (770.4 avg.)	689, 413, 574, 463 640, (555.8 avg.)
20	903, 674, 527, 636 450, (638.0 avg.)	561, 383, 428, 290 310, (394.4 avg.)	307, 482, 407, 327 483, (401.2 avg.)

Subject	Resting	1 Bit	2 Bit
21	510, 614, 545, 552 740, (592. 2 avg.)	557, 420, 405, 500 240, (424. 4 avg.)	255, 230, 320, 300 305, (282. 0 avg.)
22	504, 730, 660, 607 580, (616. 2 avg.)	331, 280, 560, 298 437, (381. 2 avg.)	485, 420, 435, 613 233, (437. 2 avg.)
23	595, 725, 550, 586 490, (589. 2 avg.)	363, 647, 220, 577 707, (502. 8 avg.)	330, 227, 503, 348 275, (336. 6 avg.)
24	577, 431, 477, 469 647, (520. 2 avg.)	415, 230, 375, 413 410, (368. 6 avg.)	268, 260, 318, 286 400, (306. 4 avg.)

Heart Beat in Beats Per Minute for Minutes 3 to 7

Subject	Resting	1 Bit	2 Bit
1	84, 86, 87, 86 84, (85. 4 avg.)	81, 84, 85, 84 84, (83. 6 avg.)	84, 84, 83, 86 81, (83. 6 avg.)
2	74, 74, 73, 77 73, (74. 2 avg.)	77, 79, 78, 78 79, (78. 2 avg.)	75, 76, 73, 78 76, (75. 6 avg.)
3	73, 77, 76, 78 76, (76. 0 avg.)	79, 74, 77, 81 79, (78. 0 avg.)	77, 77, 80, 80 80, (78. 8 avg.)
4	77, 79, 78, 80 75, (77. 8 avg.)	75, 77, 75, 74 76, (75. 4 avg.)	74, 73, 73, 73 73, (73. 2 avg.)
5	64, 65, 62, 61 63, (63. 0 avg.)	59, 60, 62, 62 63, (61. 2 avg.)	61, 62, 62, 61 63, (61. 8 avg.)
6	90, 88, 89, 88 89, (88. 8 avg.)	88, 92, 93, 93 92, (91. 6 avg.)	89, 85, 88, 86 86, (86. 8 avg.)
7	90, 88, 93, 85 85, (88. 2 avg.)	93, 91, 89, 88 92, (90. 6 avg.)	86, 83, 88, 86 88, (86. 2 avg.)
8	55, 55, 52, 50 52, (52. 8 avg.)	50, 52, 53, 53 52, (52. 0 avg.)	51, 51, 53, 51 52, (51. 6 avg.)
9	84, 87, 92, 88 87, (87. 6 avg.)	90, 91, 91, 89 91, (90. 4 avg.)	91, 91, 92, 91 92, (91. 4 avg.)
10	63, 60, 61, 66 67, (63. 4 avg.)	60, 63, 63, 62 62, (62. 0 avg.)	62, 60, 63, 61 64, (62. 4 avg.)
11	81, 82, 82, 84 83, (82. 4 avg.)	79, 83, 81, 83 80, (81. 2 avg.)	81, 83, 84, 85 84, (83. 4 avg.)
12	64, 60, 62, 63 63, (62. 4 avg.)	57, 57, 58, 59 64, (59. 0 avg.)	59, 60, 66, 64 63, (62. 4 avg.)
13	80, 78, 80, 85 81, (80. 8 avg.)	78, 81, 80, 81 76, (79. 2 avg.)	78, 80, 79, 80 78, (79. 0 avg.)
14	81, 78, 83, 80 79, (80. 2 avg.)	72, 72, 75, 75 74, (73. 6 avg.)	74, 74, 76, 74 74, (74. 4 avg.)
15	64, 62, 57, 60 58, (60. 2 avg.)	54, 53, 56, 54 5, (54. 4 avg.)	57, 55, 54, 53 59, (55. 6 avg.)

Subject	Resting	1 Bit	2 Bit
16	72, 71, 74, 72 73, (72.4 avg.)	62, 62, 61, 62 62, (61.8 avg.)	63, 62, 63, 64 62, (62.8 avg.)
17	84, 84, 82, 78 79, (81.4 avg.)	76, 76, 78, 79 78, (77.4 avg.)	78, 77, 77, 76 76, (76.8 avg.)
18	80, 79, 81, 79 76, (79.0 avg.)	73, 72, 72, 73 72, (72.4 avg.)	69, 70, 70, 68 72, (69.8 avg.)
19	71, 73, 69, 72 72, (71.4 avg.)	69, 67, 65, 66 69, (67.2 avg.)	66, 65, 68, 64 68, (66.2 avg.)
20	83, 85, 88, 83 90, (85.8 avg.)	85, 84, 85, 85 87, (85.2 avg.)	86, 87, 89, 86 84, (86.4 avg.)
21	70, 72, 74, 69 75, (72.0 avg.)	66, 69, 68, 69 65, (67.4 avg.)	66, 66, 67, 68 65, (66.4 avg.)
22	58, 62, 64, 66 64, (62.8 avg.)	63, 65, 65, 63 63, (63.8 avg.)	62, 61, 58, 63 62, (61.2 avg.)
23	90, 85, 90, 91 91, (89.4 avg.)	85, 84, 87, 87 84, (85.4 avg.)	85, 89, 84, 85 88, (86.2 avg.)
24	81, 79, 80, 79 81, (80.0 avg.)	78, 77, 75, 76 75, (76.2 avg.)	78, 79, 79, 77 76, (77.8 avg.)

BIBLIOGRAPHY

1. Bell, D. A., Information Theory and its Engineering Applications, Sir Isaac Pittman and Sons Ltd., London 1953.

2. Corday and Irving, Disturbances of Heart Rate, Rhythm and Conduction, W. B. Saunders Company, Philadelphia, 1961.

3. Craig and Cummings, "Slowing of the Heart at the Beginning of Exercise", Journal of Applied Physiology, v. 18, p. 353-356, 1961.

4. Davies and Neilson, "Sinus Arrhythmia in Man at Rest", Journal of Applied Physiology, v. 22, p. 947-955, May 1967.

5. Dixon, W. J., Biomedical Computer Programs, University of California Press, Los Angeles, 1968.

6. Dreifus, L. S., Cariac Arrhythmias, Lederle Laboratories, Pearl River, New York, 1966.

7. Graybill, F. A., An Introduction to Linear Statistical Models, Volume 1, McGraw Hill Book Company, Inc., New York, 1961.

8. Herrmann, G. R., Synopsis of Diseases of the Heart and Arteries, C. V. Mosby Company, St. Louis, 1944.

9. Hicks, C. R., Fundamental Concepts in the Design of Experiments, Holt, Rinehart and Winston, Inc., New York, 1965.

10. Kalsbeek, J. W. H., "Measurement of Mental Work Load and of Acceptable Load: Possible Applications in Industry", International Journal of Production Research, v. 7, p. 33-45, 1968.

11. Lown and Levine, Atrial Arrhythmias, Digitalis and Potassium, Appleton-Century Crofts Inc., New York, 1959.

12. Poock, G. K., "Prediction of Elemental Performance Using Personnel Selection Tests", Ph. D. Dissertation, University of Michigan, 1967.

13. White, P. D., Heart Disease, The MacMillan Company, New York, 1951.

14. Winer, B. J., Statistical Principles in Experimental Design, McGraw Hill Book Company, Inc., New York 1962.

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13. ABSTRACT

This experiment investigated the effect of increased information processing on heart beat and sinus arrhythmia. A measure of sinus arrhythmia was developed which considered the area between the electrocardiogram rate curve and the average heart beat line. Simple linear correlation analyses were performed to determine the relationships between heart beat, sinus arrhythmia and information processing rate. Sinus arrhythmia was decreased as a result of increased information processing while heart beat was not significantly affected.

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